1271543

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(54) SLIDABLE HOT RUNNER FOR INJECTION MOLDS

(71) I, LADISLAO (WLADYSLAWI) PUTKOWSKI, of 21 Limarick Avenue, Weston, Ontario, Canada, a citizen of Canada, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to an improved hot runner system for injection molds for plastics material.

In the art of injection molding, molten plastic is usually supplied under high pressure by an injection molding machine to a mold structure, where it is received by a sprue bushing. From the sprue bushing, the plastic is commonly conducted by conduits called runners to nozzles leading into various mold cavities (or to different parts of the same cavity). The runners are often heated, in which case they are called hot runners. When the plastic finally enters the mold cavity, it freezes to form a desired part. To ensure rapid freezing, the mold structure is usually water cooled in the vicinity of the cavity.

Difficulties have been experienced in the past with hot runner systems for the following reason. In the past, the hot runners were usually formed by channels machined in a large block located next to the mold cavity plate. The temperature differential between the hot runner block and the relatively cold mold plate caused the block to expand to a greater extent than the plate, and this tended to cause tilting of the nozzles (usually firmly located in the hot runner block to avoid leakage) directing plastic into the mold cavity. Since the opening through which a nozzle discharges into the mold cavity is very small and must be precisely aligned, tilting of the nozzles often leads to improper operation.

Accordingly, it is an object of this invention to provide a simple hot runner system which reduces the effects of differential expansion. To this end, the invention provides for an injection mold structure for plastics material, a hot runner system comprising: a first member located in said mold structure, said first member having a bore therein; a second member located in said mold structure at a position spaced from said first member, a tubular member for conducting molten plastics material between said first and second members, said tubular member having a first tubular end sealingly but slidably fitted into said bore and a second end sealingly connected to said second member, said first end of said tubular member being slidable in said first bore to permit substantially unobstructed expansion and contraction of said member relative to said first member in a direction parallel to the axis of said tubular end, and a heater coupled to said tubular member between said first and second ends to heat said plastics material flowing through said tubular member.

Further features of the invention will appear from the following disclosure of illustrative embodiments, taken together with the accompanying drawings, in which:

Fig. 1 is a sectional view showing a sprue bushing, hot runner and gate insert in position on a cavity plate;

Fig. 1A is a bottom plan view of a stem member of Fig. 1;

Fig. 2 is a section along lines 2—2 of Fig. 1 with a front plate removed and with a spacer plate shown only in dotted outline;

Fig. 3 is a sectional view showing a portion of a modified hot runner and gate insert in position on a cavity plate;

Fig. 4 is a perspective view of a piston of Fig. 3;

Fig. 5 is a view similar to Fig. 3 showing a further modification of the invention;

Figs. 6 and 7 are enlarged top plan views of a stem shown in Fig. 5; the shading being indicative of areas X, Y and Z and not indicative of sectioning;

Fig. 8 is a bottom plan view of the stem of Fig. 5;

Fig. 9 is a sectional view of a further embodiment of the invention; and

Fig. 10 is a sectional view of a portion of

a modified connection of a hot runner to a sprue bushing.

Reference is first made to Figs. 1 and 2, and particularly Fig. 1, where there is shown a mold cavity plate 2 forming with another plate 4 a cavity 6 into which molten plastics material (herein termed plastic for brevity) is to be injected to form a desired part. Cooling channels (not shown) are provided in the cavity plate 2 to permit flow of cooling water therethrough. Connected to the cavity plate 2 are three further plates, namely a rear plate 8, a spacer plate 10 (shown in dotted outline in Fig. 2), and a front plate 12. The rear plate 8 and spacer plate 10 are fastened together and to the cavity plate by screws (not shown), and the front plate 12 is fastened to the spacer plate 10 by screws 14.

The front plate 12 serves to clamp in position a sprue bushing generally indicated at 16. The sprue bushing 16 receives molten plastic from an injection molding machine (not shown) by way of a central axial channel 18, and then directs this plastic outwardly through a radial bore 20. A relieved portion 22 at the bottom of the sprue bushing 16 reduces heat transfer from the hot sprue bushing through rear plate 8 to the cool cavity plate 2.

From the sprue bushing 16, the molten plastic travels through a hot runner generally indicated at 24 and is then injected through a gate (i.e. an outlet aperture) 26 in a gate insert member 28 and then passes into the mold cavity 6.

The hot runner 24 comprises a tubular member 30 having a first end 32 snugly but slidably fitted into the bore 20 in the sprue bushing, and a second end 34 screwed into a threaded bore 36 in the gate insert member 28. The thread of the bore 36 has at its end a standard thread relief groove 37. Because the axes of the bores 20, 36 are orientated in the same plane but at right angles to each other, the tubular member 30 has a right angle bend indicated at 38 in its centre, so that it is shaped generally in the form of a letter L.

Plastic flowing through the tubular member 30 is maintained at desired temperature by a pair of heaters 40, 42 which encircle the tubular member 30 on each side of the bend 38. The heaters 40, 42 are conveniently made by selecting a ceramic tube of a diameter to fit over member 30, winding a heater wire around the ceramic tube, placing the resulting combination in a metal sleeve, and injecting an appropriate bonding material or cement between the ceramic tube and metal sleeve. Between the heaters 40, 42 thre is located a bushing 44 of insulating material such as ceramic.

The inner diameter of the outlet end of the tubular member 30 is enlarged as shown at 46 to accommodate a stem 48. The stem 48 is press fitted into the end of the tubular member 30 before the tubular member 30 is screwed into the bore in the gate insert member 28. The gate insert member 28 is snugly but slidably fitted into the mold cavity plate 2.

The stem 48 has an axial interior bore 49 and three spaced outlet passages 50 directing plastic into a space 50a between a reduced diameter tip 51 of the stem and the gate insert member 28. From the space 50a the plastic flows into the gate 26. The tip 51 of the stem 48 penetrates into the gate 26 but is spaced from the walls of the gate by a few thousandths of an inch to allow plastic to pass through the gate into the mold cavity 6.

The arrangement shown, by which the molten plastic is directed through spaced passages in the stem 48, into the top of the space 50a, keeps the plastic in space 50a flowing and prevents plastic stagnation or freezing. The stem 48 is preferably made of a better heat conductor material (e.g. berillium copper) than that of the tubular member 30, to conduct heat to the plastic flowing through the gate 26 to prevent freezing in the gate. The total sectional area of passages 50 is approximately equal to that of bore 49.

The hot runner 24 further includes a short upper tube 52 welded to the bend 38 of the tubular member 30. The tube 52 contains a threaded bore to receive a bolt 56 having a thread 54. The bolt holds the hot runner in position relative to the spacer plate 10.

It will be noted that the left hand end 32 of the tubular member 30 is spaced from the inner end of the bore 20 in the sprue bushing 16. This allows the hot runner to expand in the direction of arrows A—A as the hot runner is heated, without tilting the axis of the gate insert member 28 relative to the cavity plates 2,4. The amount of room needed to allow for lengthwise expansion of the tubular member 30 in the direction of arrows A—A is fairly small. For example, if the member 30 is stainless steel and is four inches long in the direction of arrows A—A (this is a typical length), then it will expand approximately only twenty-thousandths of an inch during heating to operating temperature. However, if the expansion room described were not provided, then differential expansion between tubular member 30 and cavity plate 2, even though slight, would cause misalignment of the gate insert member and would cause difficulty in molding. The spacing between the end of tube 30 and the inner end of bore 20 is sufficient to allow for the maximum expected expansion of tubular member 30.

Tubular member 30 is preferably made of a material having a greater thermal coefficient of expansion than the material of the

sprue bushing 16. For example, tubular member 30 can as indicated be made of stainless steel, while the sprue bushing can be made of tool steel. This permits easy assembly of the parts while they are cool, with a snug but slidable fit when they are hot.

Similar provision for expansion is made at the other end 34 of the tubular member 30, because of the sliding fit between the gate insert member 28 and the cavity plate 2. The dimensions of the parts are preferably made such that the lower surface of the gate insert member 28 is above the adjacent lower surface of the cavity plate 2 when the parts are cold, but when the parts (including the vertical leg of tubular member 30) expand (in the direction of arrows B—B) on heating to operating temperature, the lower surface of the gate insert member 28 becomes flush with the adjacent lower surface of plate 2 as shown.

Although provision for expansion in the direction of arrows B—B is preferred, it is not so essential as provision for expansion in the direction of arrows A—A, because of the clamping pressure of the injection molding machine which is applied in the direction of arrows B—B and would counteract much of the expansion. Thus the gate insert member 28 could if desired be screwed into the cavity plate 2. In any event, slight axial expansion of the vertical leg of member 30 will not normally cause serious difficulties.

Although the sprue bushing 16 has been shown as having only one bore 20, it can be provided with a number of radial bores as indicated in dotted lines at 58, to feed other hot runners. The hot runners may be made in various lengths as required.

It will be noted that the hot runner 24 is largely separated from the rear plate 8 by air gaps 60, 62. In fact, the hot runner contacts the plates 8, 10 and the cold mold plates only at three points, i.e. at the sprue bushing, the tip of the upper tube 52, and the gate insert member 28. This reduces heat transfer from the runner to rear plate 8 and hence to the cavity plates, and yet the hot runner is securely held in position.

Reference is next made to Fig. 3, which shows an arrangement similar to the Figs. 1 and 2 embodiment, and wherein primed reference numerals indicate parts corresponding to those of Figs. 1 and 2. The Fig. 3 embodiment differs from the Figs. 1 and 2 embodiment in that the stem 48′ is made movable and is upowered externally, so that the gate 26′ can be opened and closed as desired. To this end, the bore 46′ in the tip of the tubular member 30′ is made of diameter such that the stem 48′ can slide snugly but smoothly therein, and the bore 46′ is made long enough so that there is clearance 70 between the upper end of the stem 48′ and the upper end of the bore 46′ when the stem 48′ is in its lowermost position. When the stem 48′ is in its lowermost position, it completely blocks and closes the gate 26′, and when the stem 48′ is raised, plastic is permitted to flow through the gate. A typical stroke for the stem 48′ is .020 inches.

The stem 48′ is driven by a piston 72 (see Fig. 4) snugly fitted within a cooperating cylinder 74 formed in the rear plate 8′. The piston 72 is inserted from the top of the rear plate and is held in position by an insert 76. The insert 76 is held against a shoulder 77 of the rear plate 8′ by the pressure of the spacer plate 10′. The piston 72 includes a central flange or ring 78, so that air may be introduced to the bottom of the flange 78 via an aperture 80 in the rear plate to drive the piston upwardly, or alternatively, air may be introduced to the top of the flange 78 via an aperture 82 to drive the piston downwardly.

The piston 72 is connected to the stem 48′ by two pins 84 which extend through holes 85 in the tip of tubular member 30′ and are screwed into the stem. Plastic does not normally escape through the holes 85 because of the tight sliding fit between the stem 48′ and the interior wall of the tip of member 30′. However, after the tight sliding fit between stem 48′ and the interior wall of the tip of member 30′ becomes loosened by wear, a small amount of plastic will escape through the holes 85. This plastic is directed to the outside of the mold through drain passages 86a in the rear plate 8′ leading to the bottom of the mold structure. The escaping plastic provides a visual indication that wear of the parts has occurred.

The pressure with which the tip of the stem 48′ can press against the gate insert member 28′ is limited by shoulders 86′ of the gate insert member, to avoid damage to the gate 26′.

Reference is next made to Fig. 5, in which double primed reference numerals indicate parts corresponding to those of Figs. 1 and 2. The Fig. 5 embodiment is similar to that of Fig. 3 in that the stem 48″ is movable, but instead of being driven by a piston, it is biased to closed position by a coil spring 90. The stem has a central radially outwardly extending collar having a lower surface 94. The spring 90 is accommodated in an enlarged diameter bore 92 in the tip of tubular member 30″ and presses against the end of the bore 92 and against a shoulder of stem 48″ to bias the stem downwardly so that its surface 94 abuts the gate insert member 28″. The stem will be forced upwardly when the pressure of the plastic becomes high enough, and will then permit plastic to pass through the gate 26″ into the mold cavity 6″. The stem is such that the area on which plastics material presses to move to stem to

the open position is greater than that on which it presses to move the stem to its closed position.

The pressure at which the stem 48″ will move upwardly can be roughly calculated as follows. Assume that the cross-sectional area of the top of the stem 48″ is X, as indicated by the shaded area in Fig. 6, the cross-sectional area of the stem at the shoulder 94 is Y, as indicated by the shaded area in Fig. 7, and the cross-sectional area of the normally closed tip 96 of the stem is Z, as indicated by the shaded area in Fig. 8.

Then the valve is closed, the plastic presses down on area X and up on area Y—Z (since tip Z lies against the gate insert member 28″ and is not acted on by the plastic) and the plastic pressure required to open the valve is

$$\frac{\text{spring pressure 90}}{\text{area Y}-(\text{area X}+\text{area Z})}$$

Once the valve is open, the plastic presses down on area X and up on area Y and the pressure required to hold the valve open is

$$\frac{\text{spring pressure 90}}{\text{area Y}-\text{area X}}$$

By way of example, if the areas are Y=.1503 square inches, X=.0767 square inches, Z=.0048 square inches, and spring pressure 90 is 30 pounds, then (a) valve opening pressure is 447 psi, (b) pressure to hold valve open is 410 psi, and (c) valve closing pressure is spring pressure÷area Z, which is 6000 psi, with no plastic pressure.

It will be noted in the Fig. 5 valve that holes 85″ are provided in the tip of the member 30″. The upper edges of holes 85″ are above the level to which shoulder 94 on stem 48″ can move and permit escape of air from bore 92 when the stem 48″ is initially inserted. The holes 85″ also permit air to enter and leave the bore 92 as the stem 48″ moves up and down, thus avoiding air compression or suction which would otherwise interfere with the operation of the spring 90.

It will be appreciated that the valves of Figs. 3 and 5 can if desired be used in injection molding machines as machine nozzles, ie. to turn the flow of plastic on and off after the plastic has been melted. For the spring operated valve, the valve opening pressure can be controlled simply by varying the pressure of spring 90 and by changing the relation of areas X and Y.

Although the hot runner 24 has been shown as comprising an L-shaped tubular member 30, it can instead (see Fig. 9) be formed from a straight tubular section 100 extending in the direction of arrows A—A and fitted into a bore 102 in a nozzle 104. The tubular section 100 corresponds to and is similar to the horizontal leg of the hot runner 24 and extends into the sprue bushing, preferably with a snug sliding fit. The tubular section 100 is of course also snugly but slidably fitted into the bore 102 in the nozzle 104.

The nozzle 104 is simply a generally cylindrical member encircled by a heater and having an axial passage 106 to direct plastic towards the mold cavity. Nozzle 104 corresponds to the vertical leg of the hot runner 24 and includes at its tip a stem (not shown) similar to stem 48 which is fastened to a gate insert member, the gate insert member in turn being snugly but slidably fitted into the cavity plate. The nozzle 104 is fitted into a bore 108 in the rear plate 8‴ and a bore 110 in the spacer plate 10‴ and is held in place by a screw 112 projecting through plate 110‴. If desired, additional bores 114 can be provided in the nozzle 104 to feed plastic to additional hot runners.

Although the hot runner tubular sections and the bores in which they are fitted have been shown as extending either parallel to or at right angles to the plates of the cavity plane 2 and rear and spacer plates 8, 10, they could be directed at any angle to these plates, so long as they are slidably connected at least at one end to allow for lengthwise expansion. The invention can be used for a small single cavity mold, in which case only one straight hot runner section will be provided (either simple or valved), corresponding to the vertical leg of hot runner 24 of Fig. 1 but with a straight-through bore.

Finally, if it is desired to reduce discontinuities in the path of plastic flow, the hot runner may be designed as shown in Fig. 10, where a tubular section 116 (corresponding to the horizontal leg of hot runner 24) is slidably fitted into a bore 118 in a sprue bushing 120. The internal diamters of the passages 122, 124 in the sprue bushing and tubular section 116 are the same. The section 116 can be of calibrated length so that when it expands upon heating to operating temperature, no gap remains between its end and the inner end of bore 118, to eliminate pockets in which plastic might stick. Alternatively, as shown, a yieldable seal 126 can be provided to fill the gap between the ends of the tubular section 116 and the bore 118. The seal 126 can be copper, silver, silicone rubber, etc., depending on the temperature and plastics being used.

WHAT I CLAIM IS:—

1. For an injection mold structure for plastics material, a hot runner system comprising: a first member located in said mold structure, said first member having a bore

therein; a second member located in said mold structure at a position spaced from said first member, a tubular member for conducting molten plastics material between said first and second members, said tubular member having a first tubular end sealingly but slidably fitted into said bore and a second end sealingly connected to said second member, said first end of said tubular member being slidable in said first bore to permit substantially unobstructed expansion and contraction of said tubular member relative to said first member in a direction parallel to the axis of said tubular end, and a heater coupled to said tubular member between said first and second ends to heat said plastics material flowing through said tubular member.

2. Apparatus according to claim 1 wherein said tubular member comprises a pair of straight tubular portions oriented at right angles to each other and a connecting portion joining said straight tubular portions.

3. Apparatus according to claim 1 or 2 wherein said tubular member is separated by air gaps from said mold structure over a substantial portion of its length, to reduce heat transfer from said tubular member to said mold structure.

4. Apparatus according to claim 2 or 3 including a mounting portion connected to said connecting portion of said tubular member and connected to said mold structure for supporting said tubular member.

5. Apparatus according to any preceding claim wherein said second end of said tubular member is tubular and is slidable relative to said mold structure to permit substantially unobstructed expansion and contraction of said tubular member relative to said mold structure in a direction parallel to the axis of said second end of said tubular member.

6. Apparatus according to any preceding claim wherein said first member is a sprue bushing and said second member is a gate member having a gate therein for directing plastics material into mold cavity of said mold structure, and wherein said tubular member has a thermal coefficient of expansion greater than the thermal coefficient of expansion of said sprue bushing.

7. Apparatus according to any one of claims 1 to 5 wherein said mold structure includes a pair of mold cavity plates defining a mold cavity, said second member being a gate insert member slidably fitted in one of said cavity plates and having a gate for directing plastics material into said mold cavity, said second end of said tubular member being firmly connected to said gate insert member.

8. Apparatus according to any preceding claim including a movable stem slidably mounted in said tubular member, said stem member having an interior passage for plastics material and being movable between a first closed position in which it blocks egress of molten plastics material from said second member and a second open position in which it permits egress of molten plastics material from said second member.

9. Apparatus according to claim 8 wherein said stem member is slidably mounted in a tip of said tubular member, said stem member defining with said second member a chamber for plastics material and said stem member having a central radially outwardly extending collar in said chamber, so that the area on which plastics material presses to move said stem member to said open position is greater than the area on which it presses to move said stem member to said closed position, and a spring mounted in an enlarged bore in the tip of said tubular member and pressing against said collar to bias said stem member to said closed position, said enlarged bore having an escape hole therein for air, whereby said stem member will move against the pressure of said spring to its open position when the pressure of said plastics material increases beyond a predetermined level.

10. Apparatus according to claim 8 wherein said stem member is snugly but slidably mounted in a tip of said tubular member, said tip of said tubular member including a pair of holes therein substantially sealed against escape of plastics material by said snug fit of said stem member in said tip of said tubular member, said apparatus further including a pair of pins connected to said stem member and protruding through said holes in said tip of said tubular member, a cylindrical piston encircling said tip of said tubular member and connected to said pins, a cylinder encircling and guiding said piston, said piston having a central collar sliding against said cylinder, and means for admitting pressurized fluid to said cylinder on either side of said collar and for removing fluid from said cylinder on the other side of said collar to drive said piston.

11. Apparatus according to claim 8, 9 or 10 wherein said stem member is of a material of very high thermal conductivity.

12. Apparatus according to claim 6 including a stem member mounted in the end of said tubular member, said stem member having an interior passage directing plastics material into said gate, said stem member being of a material of very high thermal conductivity.

13. Apparatus according to claim 9 wherein said stem member has a substantially cylindrical portion forming said collar, and a narrowed tip, the collar having a substantially radial lower surface, said interior passage comprising an axial bore extending part way into said cylindrical portion, and a plurality of smaller passages extending from

said axial bore to said radial surface, said smaller passages being spaced around said radial surface.

14. Apparatus substantially as described and illustrated with reference to the accompanying drawings.

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1271543 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

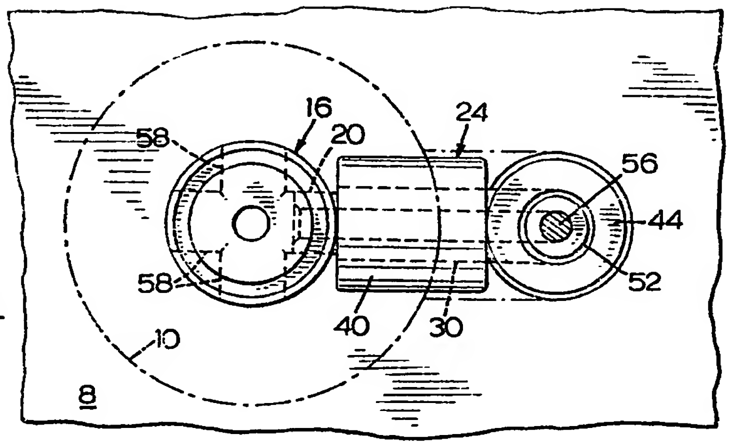

FIG. 2

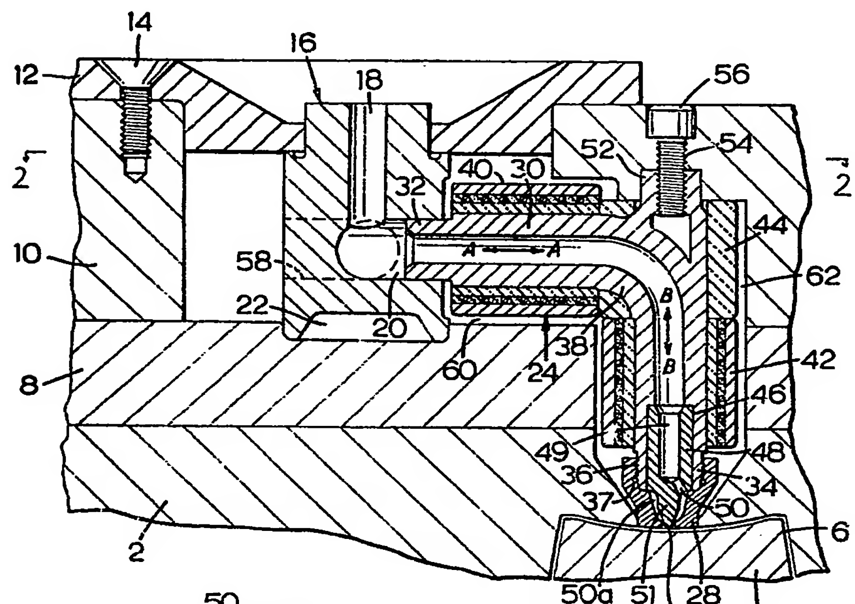

FIG. 1

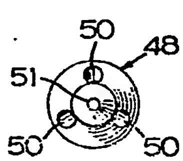

FIG. 1A

1271543 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

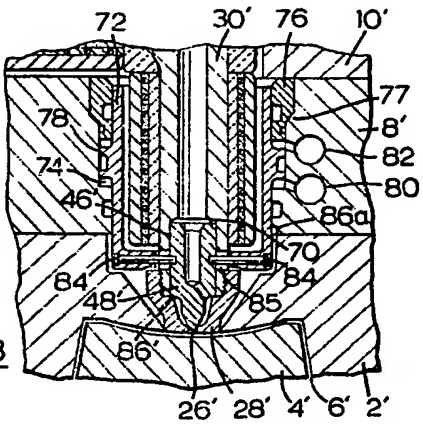

FIG. 3

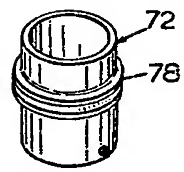

FIG. 4

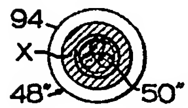

FIG. 6

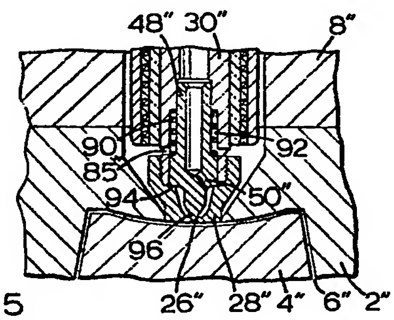

FIG. 5

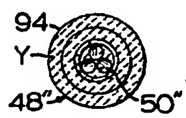

FIG. 7

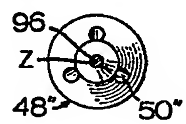

FIG. 8

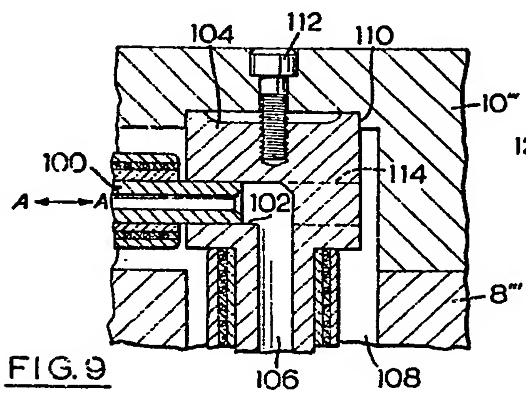

FIG. 9

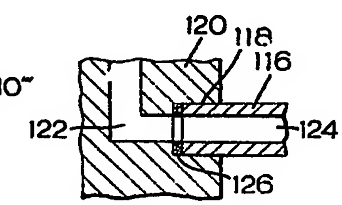

FIG. 10